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SYNOPSYS

ON

Dynamic Spectrum Sensing Technique for Wireless Communication

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DOCTOR OF PHYLOSOPY IN SCIENCE AND TECHNOLOGY IN ELECTRONICS AND TELECOMMUNICATION

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a) **Rationale and significance of the study**

In the last decade global mobile data traffic has roughly doubled each year, growth that is probable to continue increases, due mainly to the introduction of new services and features specified . Thus, the wireless industry is asked to fulfill an increase in mobile data demand by a factor of 1000 times , which is one of the most challenging requirements that the 5G system design .

There are various ways to implement the wireless network capacity, such as by designing advanced receiver techniques, new cooperative transmissions schemes, innovative smart multi-antenna solutions, and an effective implementation of heterogeneous networks. These ways are insufficient to solve the spectrum scarcity problem .

Therefore we will discuss our results on required data traffic is to exploit additional bands, and to guarantee access to as much licensed and unlicensed spectrum as possible. Since, it is need to focus much more on enhanced, more effective, and also completely new spectrum sensing techniques.

The day by day the performance of the wireless communication applications are increases ,due to the new operators, innovative services and advanced technologies during the last few years has resulted, under this static authoritarian system, in the overtiredness of spectrum bands with commercially attractive radio propagation characteristics.

b) A survey of work done in the research area and the need for more research

Cognitive radios are reactive devices that identify unused spectrum segments known as spectral holes and dynamically adjust their transmission characteristics into these holes while avoiding interference with licensed/primary users. They are an extension of software-defined radios envisioned by Joseph Mitola [14] and must be cognizant of spectral, temporal and spatial components of the environment in which they are operating.

Cognitive Radio technology has proven to be an effective way to enable Dynamic Spectrum Access (DSA) to improve the spectrum utilization efficiency in Cognitive Radio Networks (CRN) [10].The key challenge in CRN is how to utilize the spectrum resources efficiently. To handle the challenge, designing an efficient spectrum assignment (SA) mechanism is a possible solution [11], [12]. According to [11], the general design process of a SA mechanism includes three steps: first, to select a criteria to define the target objectives; second, to formulate a SA problem that best fits to environment for a suitable band, employ an intelligent agent for decision-making and a frequency-agile radio that can be tuned to a wide range of frequency bands and, eventually, operate on an intelligently the target objective; third, to select the most suitable technique to solve the SA problem.cognitive radio network (CRN) is formed by advanced radio devices, which observe the radio selected band. Motivated by the spectrum utilization and regulation issue for exclusive use by the licensed or primary users (PUs), it brings a revolutionary change in this new paradigm by introducing a new class of unlicensed or secondary users (SUs) who can share the spectrum opportunistically without interfering with the primary users[13].The definition adopted by Federal Communications Commission (FCC): “Cognitive radio: A radio or system that senses its operational electromagnetic environment and can dynamically and autonomously adjust its radio operating parameters to modify system

operation, such as maximize throughput, mitigate interference, facilitate interoperability, access secondary markets." [15].

In order to deal with the rapidly expanding market of wireless broadband and multimedia users, and high data-rate applications, the next generation of wireless networks, i.e., the fifth generation (5G) envisions to provide 1000 times increased capacity, 10-100 times higher data-rate and to support 10-100 times higher number of connected devices as compared to the current 4G wireless networks [2]. However, the main limitation in meeting these requirements comes from the unavailability of usable frequency resources caused by spectrum fragmentation and the current fixed allocation policy. In this context, one key challenge in meeting the capacity demands of 5G and beyond wireless systems is the development of suitable technologies which can address this spectrum scarcity problem [3]. Two potential ways to address this problem are the exploitation of additional usable spectrum in higher frequency bands and the effective utilization of the currently available spectrum. Due to the scarcity of radio spectrum in the conventional microwave bands, i.e., < 6 GHz, the trend is moving towards millimeter wave (mmWave) frequencies, i.e., between 30 GHz and 300 GHz, since these bands provide much wider bandwidths than the traditional cellular bands in the microwave range, and also enable the use of highly directional antenna arrays to provide large antenna directivity and gain [4, 5]. In this direction, there are several recent research works examining the usage of mmWave for future cellular communications [4]. With the help of statistical models derived from real-world channel measurements at 28 GHz and 73 GHz, it has been demonstrated that the capacity of cellular networks based on these derived models can provide an order of magnitude higher capacity than that of the current cellular systems [4]. However, several research challenges including propagation-related issues such as shadowing and mobility aspects, hardware imperfections like power amplifier nonlinearity, and the need of high processing power and large

antenna arrays have to be addressed to enable the operation of future cellular communications in mmWave bands [8]. The other challenging solution is the problem of spectrum scarcity to enhance the utilization of available radio frequency bands by employing Dynamic Spectrum Sharing (DSS) mechanisms . In recent advances in software defined radio, advanced digital processing techniques and wideband transceivers have led to the feasibility of this solution by enhancing the utilization of radio frequencies in a very flexible and adaptive manner .

Secondary transmissions are allowed following this operating principle as long as they do not result in harmful interference to primary radios. The temporarily unused portions of spectrum are called spectrum White Spaces (WSs) that may exist in time, frequency, and space domains. In the specific DSA context, the following definition given in is the most cited one:

"*Cognitive radio is an intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to learn from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters (e.g., transmit-power, carrier-frequency and modulation strategy) in real-time, with two primary objectives in mind: highly reliable communications whenever and wherever needed; efficient utilization of the radio spectrum.*"

According to this definition, the tasks of the CR cycle should be characterized in the context of DSA in order to enable the following capabilities :

• Radio-scene analysis, which consists in estimating interference conditions of the radio environment and identifying the set of available spectrum holes or WSs.

SPECTRUM SENSING:

Spectrum sensing deals with signal detection and is the enabling technology behind cognitive radio, which detects the presence of a primary user (PU) signal within a given frequency band. Spectrum sensing seeks to distinguish between a band containing a PU signal, s(t), or additive white Gaussian noise, n(t), and is given by the hypotheses:

$$H0 : x(t) = n(t)$$

$$H1 : x(t) = s(t) + n(t)$$

where H0 is the hypothesis the band is a spectral hole and

H1 is the hypothesis the band contains a PU signal.

Non-coherent signal detection, such as energy detection, requires little to no prior knowledge of the PU signal and does not require synchronization. Energy detectors compute the energy contained in a frequency band and compare the magnitude of the power spectrum to a threshold based on the estimated noise power to determine if a signal is present. Low power implementation of spectrum sensing can result in a substantial overall power savings for a cognitive radio receiver.

Spectrum Sensing Methods For Cognitive Radio

The literature for spectrum sensing number of different methods are proposed for identifying the presence of signal transmissions.

A. Energy Detector Based Sensing

Energy detector based approach, also known as radiometry , is the most common way of spectrum sensing because of its low computational and implementation complexities [16], [17]. It is more generic as receivers do not need any knowledge on the primary users' signal. The signal is detected by comparing the output of the energy detector with a threshold which depends on the noise floor [18]. Some of the challenges with energy detector based sensing include

selection of the threshold for detecting primary users, inability to differentiate interference from primary users and noise, and poor performance under low signal-to-noise ratio (SNR) values.

B. Waveform-Based Sensing

Known patterns are usually utilized in wireless systems to assist synchronization or for other purposes. Such patterns include preambles, midambles, regularly transmitted pilot patterns, spreading sequences etc. A preamble is a known sequence transmitted before each burst and a midamble is transmitted in the middle of a burst or slot. In the presence of a known pattern, sensing can be performed by correlating the received signal with a known copy of itself. This method is only applicable to systems with known signal patterns, and it is termed as waveform-based sensing or coherent sensing. [17]

C. Cyclostationarity-Based Sensing

Cyclostationarity feature detection is a method for detecting primary user transmissions by exploiting the cyclostationarity features of the received signals [16]. Cyclostationary features are caused by the periodicity in the signal or in its statistics like mean and autocorrelation or they can be intentionally induced to assist spectrum sensing [20]. Instead of power spectral density (PSD), cyclic correlation function is used for detecting signals present in a given spectrum. The cyclostationarity based detection algorithms can differentiate noise from primary users' signals. Furthermore, cyclostationarity can be used for distinguishing among different types of transmissions and primary users .

D. Radio Identification Based Sensing

A complete knowledge about the spectrum characteristics can be obtained by identifying the transmission technologies used by primary users. Such an identification enables cognitive radio with a higher dimensional knowledge as well as providing higher accuracy [21].

E. Matched-Filtering

Matched-filtering is known as the optimum method for detection of primary users when the transmitted signal is known [22]. The main advantage of matched filtering is the short time to achieve a certain probability of false alarm or probability of miss detection [23] as compared to other methods that are discussed in this section. In fact, the required number of samples grows as O(1/SNR) for a target probability of false alarm at low SNRs for matched filtering [23]. However, matched-filtering requires cognitive radio to demodulate received signals. Hence, it requires perfect knowledge of the primary users signaling features such as bandwidth, operating frequency, modulation type and order, pulse shaping, and frame format.

F. Other Sensing Methods

Other alternative spectrum sensing methods include multitaper spectral estimation, wavelet transform based estimation, Hough transform, and time-frequency analysis. The proposed algorithm is shown to be an approximation to maximum likelihood PSD estimator, and for wideband signals, it is nearly optimal. Although the complexity of this method is smaller than the maximum likelihood estimator, it is still computationally demanding. Random Hough transform of received signal is used in [24] for identifying the presence of radar pulses in the operating channels of IEEE 802.11 systems. This method can be used to detect any type of signal with a periodic pattern as well. Statistical covariance of noise and signal are known to be different.

c) A statement of aims and objectives

To allow spectrum sharing among various radio communication systems with efficient and optimizing the utilization of spectrum.

The research problem is focus on modeling cognitive management frameworks that provide innovative strategies for Spectrum sensing under an energy efficiency constraint .In this importance is given the importance of green communications. The efficient designs that may consume less energy and good performance in cognitive radio networks.

It is also focus on simulation of cognitive radio framework that provide innovative methods which will be used in various uses in networks context of dynamic spectrum sensing. The spectrum sensing technique is to identify spectrum opportunities, coordination of opportunistic spectrum access among different users, spectrum selection strategies .The key challenge in CRN is how to utilize the spectrum resources efficiently.

Motivation

Spectrum sensing is in the core of mobile and wireless communications. In last decades, wireless communication has progressed from a useful network to a necessity, and its importance is expected to grow further. From this point of view, radio spectrum enables interconnection of stationary infrastructures such as cities, houses, hospitals, schools, etc., activities like health, education, public transport, production, logistic, entertainment, etc. and mobile users humans, devices and even animals. Spectrum is a limited source which is subject to technological and cost-effective constraints. Technology enables increasingly efficient use of spectrum.

A Real time spectrum sensing is utilized for efficient searching of possible signal at a specific time ,frequency and location .The system is utilized the two mode i.e detection and receiving of signal .The motivation by the fact that a significant amount of licensed radio

spectrum remains under-utilized in the spatial and temporal domains, and thus it aims to address the possibility between the spectrum shortage and under-utilization

The recent allocation of the new spectrum released by the digitalization in the digital TV broadcast in this dynamic spectrum sensing technique and the related dynamic spectrum management (DSM) have become a major topic of interest. A dynamic assignment of spectrum in time and place has a potential to significantly increase the economic efficiency by rapidly reallocating the spectrum allocate efficiency, development innovation and emerging services i.e dynamic efficiency, and contributing in the redistribution of resources by allowing new entrants.

d) Methodologies and techniques to be used

Cognitive Radio (CR) prototype represents an innovative and efficient solution to mitigate the spectrum scarcity problem by enabling Dynamic Spectrum sensing technique, defined in order to pacify the offered conflicts between the ever-increasing spectrum require growth and the currently inefficient spectrum utilization. The basic idea of DSA is to provide proper solutions that , the first solution is development of new algorithm for spectrum sensing analyze the simulation results which will provide the efficient spectrum management for opportunistic Networks (ONs) . Further the system is development based on the cognitive radio cycle to support the ONs is considered a key aspect to allow autonomous decisions and reconfiguration ability mechanisms because of the temporarily nature of these networks and the highly dynamic nature of the radio environment.

Then, in order to expand the design of cognitive management frameworks providing spectrum management solutions that have applicability in a number of different scenarios and use cases. Next is to propose to combine the cognitive radio capabilities of radio environment with a statistical component of the system dynamics. Further the system is extend with the new

functionality to demonstrate characterization of radio environment that will combine among of statistical evaluating of system dynamics which get the efficient system.

From a methodological point of view, the development and assessment of the proposed system and the related spectrum sensing technique occupy analytical studies, system-level simulations and a real-time platform implementation.

- **To Design and Implementation of a simulation model based on Cognitive Radio .** The develop a simulation model that has been specifically designed and implemented with the aim of provided that an model to assess the spectrum sensing technique based on the cognitive cycle initially in a simplified radio environment. Then, the simulator has been extended in order to implement with the algorithm that provides efficient spectrum sensing technique.
- **To Design and Implementation of a real-time test with H/W S/W co-simulation for Dynamic spectrum sensing technique.** Real-time implementation of algorithm enable to carry out practical scenarios to test algorithms, policies, protocols, services and applications under realistic conditions, thus constituting a powerful tool for assessing not only the Quality of Services(QoS) but also the Quality of Experience (QoE) .

With this inspiration, an evolutionary real-time testbed has been used, implemented and validated to evaluate in a real environment the spectrum management strategies proposed . The testbed to be developed for demonstrating and validating the H/W S/W co-simulation of cognitive spectrum management . It is based on reconfigurable devices that can transmit/receive in different frequencies dynamically configured. This allows establish and monitor radio links, and reconfiguring them based on the actual changes in the current spectrum conditions. Hence, through the testbed the proposed framework and the corresponding spectrum management strategies have been assessed in a real-time environment.

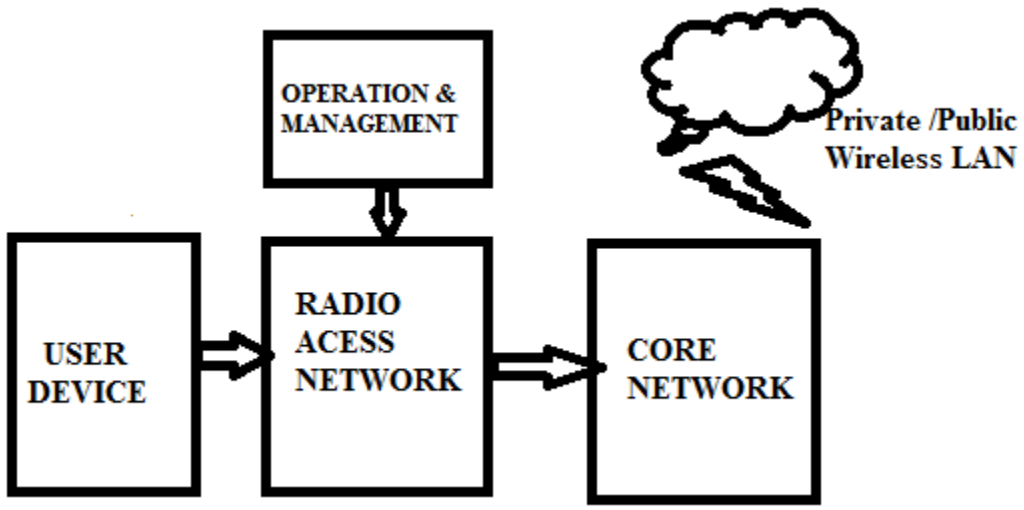

Figure 1.: Proposed Method For Simulation

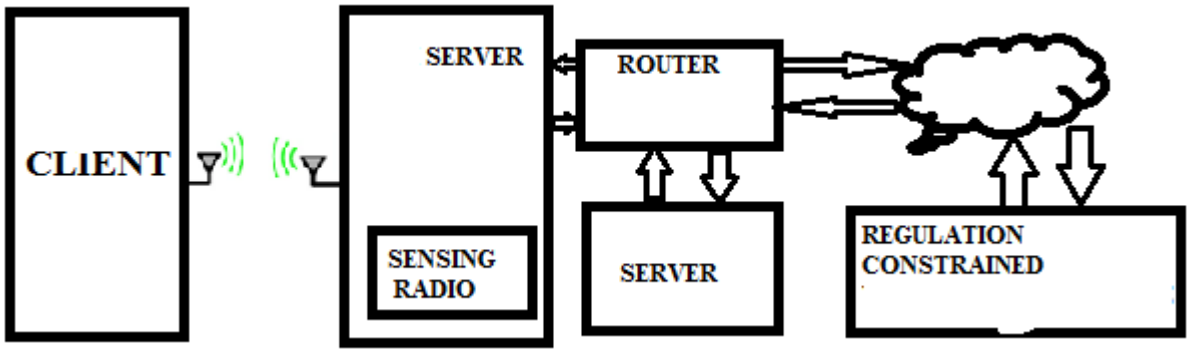

Figure 2.: Proposed Method for Hardware software co-simulation

Purpose of Tools ,Software's and Hardware platforms :

- ***OPNET:*** OPNET modeler wireless suite provides high performance in modeling and simulation.
- ***CRTS:*** Flexible framework to evaluate cognitive radio networks
- ***NetSim:*** Network simulation and simulation tool for designing cognitive radio networks

- ***CogNS:*** Cognitive radio networks simulation framework based on NS2 simulator
- ***MATLAB:*** 4th generation programming language that used to simulate a centralized cognitive radio network.
- ***GNU Radio***
- ***CrSimulator:*** OMNET++ based simulator used for spectrum sharing in cognitive radio networks
- ***OMNET++/MiXiM:*** Cognitive radio simulation platform to support DCF medium access policy with IEEE802.11b.
- ***CRCN:*** Software based network simulator for cognitive radio cognitive network level simulations.
- ***CRE-NS3:*** Extension of NS3 simulator we call this extension module for cognitive radio.
- ***SEAMCAT:*** Open source freely available software tool which is used to evaluate interference potential for different radio communication technologies.
- ***MCRNSim:*** Mobile cognitive radio network simulator compatible with .net 4.0 written in C# for simulating cognitive radio networks.

Hardware Platforms :USRP Board

e) The kinds of conclusions expected and their possible value

In this way advanced wireless communication the cognitive Radio is consider a key solutions to mitigate the spectrum scarcity problem. In first part we develop a different algorithm for dynamic spectrum sensing technique and in next part the H/W, S/W co simulation experimentation is carried out to verify the real time results verification with parameter estimation with the improved efficiency.

f) Plan of research

Sr.no.	Activity planned	Duration	Remark's
1.	Detail Study of Cognitive Radio , Communication fundamentals and Signal processing aspects	3 Month	
2.	Literature Review in detail & write a research Paper in Literature Review	4Month	
3.	Study of various Software Tools & implement the modules /Proposed CR architecture	3 Month	
4.	Analytical review of the proposed work & correlated with the work done compare it & publish the work .	4 Month	
5.	Implement the small module with the hardware platform & compare the result with the simulation	3 Month	
6.	Work with the proposed Opportunistic Networks & Publish the work done	4 Month	
7.	Detail study with the proposed methods and compare with existing methods of spectrum managements	4 Month	
8.	Evaluation Of Simulation and work on performance results & publish the work done with simulation results .	3Month	
9.	Evaluation with real time Testbed work on performance results & Publish the work done with Results	4Month	
10.	Work with the Overall proposed model start of thesis writing .	4 Month	

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